

CERCIDIPHYLLACEAE HARDY IN TEMPERATE NORTH AMERICA¹

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CERCIDIPHYLLACEAE Engler, Syllabus Pflanzenfam. ed. 6. 132. 1909,
nom. cons.

(CERCIDIPHYLLUM FAMILY)

A small, isolated family of dioecious trees producing long and short shoots with stipulate, dimorphic leaves exhibiting either palmate or nearly palmate venation, the short shoots producing solitary leaves and ultimately staminate or carpellate inflorescences; staminate inflorescences comprising several apetalous flowers, each consisting of a fascicle of numerous stamens subtended by a membranous bract; carpellate inflorescences of (2? or) 3–7 apetalous flowers, each consisting of a unilocular carpel subtended by a membranous bract. Fruit a follicle dehiscent along its abaxial suture, the numerous seeds winged at one or both ends. TYPE GENUS: *Cercidiphyllum* Siebold & Zuccarini.

A unigeneric family of eastern Asia in China and Japan. The genus *Cercidiphyllum* was initially included in the Magnoliaceae, but anatomical, palynological, and especially morphological evidence suggest that the Cercidiphyllaceae, along with the Trochodendraceae, Tetracentraceae, Eupteleaceae, and Eucommiaceae, other anomalous families with which it has been grouped, should be excluded from the magnoliaceous assemblage and aligned with the hamamelidaceous lineage, where they are more easily accommodated. Recent schemes of classification proposed by Thorne (1968, 1976), Takhtajan (1969), and Cronquist (1968) are in general agreement

¹This treatment of the Cercidiphyllaceae is the sixth contribution in a series of treatments of cultivated ligneous plants, the preparation of which is a project of the Arnold Arboretum of Harvard University, and the purpose of which is to provide a modern, accurate account of the woody plants encountered in cultivation in the cooler temperate regions of North America. It is hoped that these studies will eventually form the basis for a new manual of cultivated woody plants. The first paper in the series was published in the Journal of the Arnold Arboretum 56: 1–19. 1975. Reference should be made to the introductory paragraphs of that paper for matters concerning area covered, taxa included, and the general philosophy of these treatments.

Special thanks and gratitude are extended to the Director and trustees of the Stanley Smith Horticultural Trust for a grant that has made possible the illustrations that accompany this treatment. The illustrations are the careful work of Robin S. Lefberg and were prepared from living and alcohol-preserved specimens growing in and collected at the Arnold Arboretum and dried specimens in the herbaria of the Arnold Arboretum and Gray Herbarium. I extend my appreciation to Dr. S. Y. Hu for translations from the Chinese, to F. Vrugtman for specimens from the Royal Botanical Garden, Hamilton, Ontario, and to Dr. P. F. Stevens for helpful discussions.

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on this, although they differ in detail. The family Cercidiphyllaceae is nevertheless an isolated one, with no close relatives in the extant angiosperm flora. In cultivation *Cercidiphyllum* is highly valued as an ornamental shade tree and a botanical curiosity.

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Cercidiphyllum Siebold & Zuccarini, *Abh. Math.-Phys. Cl. Akad. Wiss. München* 4(3): 238. 1846; *Fl. Jap. Fam. Nat.* 2: 114. 1846.

Large, deciduous trees of sympodial growth; after a juvenile stage of long shoot growth the shoots becoming differentiated into long and short shoots, the long shoots with a small, inconspicuous pith; winter buds with 2 imbricated outer scales and 1 inner scale, the outermost scale adaxial, the buds produced on long shoots giving rise to short shoots in the second year of growth, and subsequent long shoots developed from short shoots. Leaves petiolate, involute in bud with well-developed marginal glands, stipulate, the stipules caducous or persistent, free or connate and adnate to the base of the adaxial surface of the petiole; long shoot leaves opposite and/or subopposite to alternate, with rounded to truncate bases and palmate to nearly palmate venation, those of short shoots solitary, with shallowly to deeply cordate bases and palmate venation. Flowers appearing in spring prior to and/or with the leaves in terminal, apparently greatly reduced and condensed racemes (*vide* Swamy & Bailey) from short shoots. Staminate inflorescences subsessile, consisting of numerous (upwards of 40) stamens, these aggregated into \pm distinct groups (flowers), each group \pm subtended by an erose, membranous bract; perianth absent; anther filaments at first short, elongating during anthesis; anthers reddish, basifixed, linear-oblong with conical to somewhat acute apices, 2-locular, dehiscent by longitudinal slits; pollen 3-colpate or 3-colpoidate, typically 3-lobate. Carpellate inflorescences pedunculate, the (2? or) 3-7 carpels (flowers) shortly stipitate, inserted at or toward the distal end of the peduncle, each subtended by an erose, membranous bract; perianth absent; carpels \pm cylindrical, constricted above and produced into a long slender style with 2 decurrent stigmatic ridges, these often appearing as one; ovaries unilocular with numerous anatropous, bitegmic, crassinucellar ovules on 2 parietal placentae adjacent to the abaxial suture. Fruits \pm woody follicles clustered together on the peduncle and dehiscent along the abaxial sutures; seeds numerous, small, \pm oblong in outline, the testa

winged at one or both ends; embryo small, embedded in *ab initio* Cellular endosperm, the embryo sac of the Polygonum type; embryogeny corresponding to the Caryophyllad type. TYPE SPECIES: *C. japonicum* Siebold & Zuccarini ex J. Hoffmann & Schultes. (Name from *Cercis* and Greek *phyllon*, leaf, in reference to the similarity of the leaves of short shoots to those of the redbud or Judas tree, *Cercis siliquastrum* L.) — KATSURA.

Two extant species of China and Japan; once widely distributed throughout the North Temperate Zone in Eurasia and North America and represented in the fossil record from the Late Cretaceous to the Pliocene by five described form species, of which one corresponds closely to the extant *Cercidiphyllum japonicum*.

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KEY TO THE SPECIES OF CERCIDIPHYLLUM

1. Plants with the short shoots weakly developed, to ca. 6 mm. long; stipules of short shoot leaves long, caducous; stipules of long shoot leaves free or basally connate; follicles with \pm straight to slightly recurved apices; seeds winged at the proximal end. 1. *C. japonicum*.

1. Plants with the short shoots strongly developed, to 18 mm. long; stipules of short shoot leaves short, persistent; stipules of long shoot leaves connate; follicles with strongly recurved apices; seeds winged at both ends. 2. *C. magnificum*.
1. ***C. japonicum*** Siebold & Zuccarini ex J. Hoffmann & Schultes, Jour. Asiatique, IV. 20: 282. 1852; Noms Indig. Pl. Japon Chine, 26. 1853.

FIGURES 1; 2, a-q.

Large trees to 20 or 25 m., occasionally to 35 m., with grayish black or grayish brown, deeply furrowed, and spirally twisted bark even when



FIGURE 1. *Cercidiphyllum japonicum*: habit drawing of one of the old carpellate trees growing in the Arnold Arboretum. This tree (AA #882-B) was grown from seed received at the Arnold Arboretum on April 29, 1878, that had been collected by Professor W. S. Clark in Hokkaido, Japan. Approximately 100 years old, this specimen is about 10 meters (35 feet) in height and illustrates the multiple trunks developed by many individuals of the species.

young, the plants often \pm fastigate when small, sometimes with a single trunk or often with several trunks diverging from or near the base; short shoots poorly developed, to ca. 6 mm. long; long shoots lenticellate, reddish brown, becoming silvery or grayish, the periderm exfoliating in thin sheets, the terminal portion of the current year's growth dying back and deciduous, resulting in a solitary or usually 2 opposite to subopposite pseudoterminal buds; winter buds 4–5 mm. long, acute, reddish, the outermost scale overlapping the 2 inner ones. Leaves initially reddish, becoming green or bluish green, turning yellow to pastel pink (or scarlet?) in fall, solitary on short shoots, opposite to alternate on long shoots. Long shoot leaves petiolate and stipulate, the petioles (1.3–)1.5–2 cm. long, the stipules free or basally connate, 8–9 mm. long, \pm filiform, membranous, shriveling after the blade has expanded; leaf blades 3.2–4.5 cm. long, 1.9–3.2(–3.8) cm. wide, ovate, elliptic, or slightly obovate, with rounded, truncate, or broadly cuneate bases and crenate to serrulate margins, the venation palmate to pinnate. Short shoot leaves petiolate and stipulate, the petioles 1.4–4.7 cm. long, the stipules connate, 5–6 mm. long, membranous, \pm lanceolate with lacinate, bifid or trifid apices, caducous and evident only as the leaf expands from the bud in spring; leaf blades glabrous, (3.3–)3.7–9 cm. long, (3.7–)5–8.3(–9.2) cm. wide, broadly ovate to reniform with shallowly to deeply cordate bases and crenate margins, the venation palmate; lower surfaces of the blades occasionally \pm glaucous. Inflorescences at anthesis protruding from the opening buds; staminate inflorescences consisting of numerous (20–40) stamens, the anthers ca. 5 mm. long, reddish- to pinkish-tinged, borne on slender, white filaments, these elongating at anthesis; carpellate inflorescences consisting of 3–7 carpels inserted at or near the apex of a short peduncle 3–5 mm. long, each subtended by an erose bract to 3 mm. long, the greenish ovaries ca. 3 mm. long, sessile to shortly stipitate, the styles to 14 mm. long, twisted and often curved or hooked toward the apex, the decurrent stigmas reddish to pinkish, shriveling after anthesis. Follicles initially green, becoming purplish brown, \pm glaucous and woody, 1.4–1.8 cm. long, cylindrical, slightly recurved at the apex and often with a short styler beak before dehiscence, held \pm erect and widely dehiscent along the abaxial suture at maturity, then with rounded to retuse apices and usually persistent into the following growing season; seeds numerous, small, 4–5 mm. long, closely imbricated, \pm pendulous, in 2 rows, the seed coat tan, the embryo at the proximal end, the testa forming a small, \pm oblong proximal wing. $2n = 38$. (Including *C. ovale* Maximowicz.) — KATSURA, KATSURA-TREE.

Widely distributed in mountainous areas throughout the Japanese islands of Honshu, Shikoku, and Kyushu but most common in northern Honshu and in central and western Hokkaido, where it occurs near sea level (see distribution map, p. 277, in Kurata, 1971); also known in China in Hupeh, Szechwan, and Shensi provinces (see below), and widely cultivated in North America. In Japan, where it grows in deep, rich soils, *Cercidiphyllum japonicum* is an important forest tree valued for its light, soft

wood that is utilized in cabinetry work and for the interior finish of buildings.

Plants with the lower surfaces of the short shoot leaves \pm sericeous along the veins toward the base and with puberulent follicles have been recognized as *Cercidiphyllum japonicum* f. *miquelianum* Inokuma, Bull. Tokyo Imp. Univ. Forests 25: 29. 1937 (*C. japonicum* var. *sinense* Rehder & Wilson, Pl. Wilsonianae 1: 316. 1913). This form occurs sporadically in Japan and China. Judged on the basis of herbarium specimens at A and GH, it is the most commonly collected *Cercidiphyllum* from China, occurring in Szechwan, Anhwei, and Hupeh provinces. Chinese botanists (Anonymous, 1972) record *C. japonicum* (as var. *sinense*) from the provinces listed above as well as from Shansi, Shensi, Honan, Kansu, Chekiang, and Kiangsi, but I do not know to which forms plants from these latter provinces correspond. Following Rehder and Wilson, most authors have referred specimens of *Cercidiphyllum* from China to *C. japonicum* var. *sinense*, yet some Chinese specimens, including a few cited by Rehder and Wilson in the protologue of var. *sinense*, are completely glabrous and conform to f. *japonicum*. These glabrous plants occur (based on herbarium records) in the provinces listed under the distribution given for the species.

Except for the pubescence of the leaves and follicles, plants of *Cercidiphyllum japonicum* f. *miquelianum* do not differ from typical *C. japonicum*. While Rehder and Wilson further distinguished between the two taxa on the basis of growth habit (the pubescent-leaved plants usually with a single trunk, the glabrous-leaved plants most commonly with several trunks from near or at the base), this distinction, due to exceptions and intergradations, does not appear to be of taxonomic significance. As a result, I consider that recognition of the pubescent-leaved plants is more appropriate as a form, and Inokuma's name, based on a Japanese plant, is available in that rank.

Concerning *Cercidiphyllum* in China, Wilson (in Rehder & Wilson, 1913, p. 317) noted "both in height and girth this tree exceeds all other broad-leaved deciduous trees known. . . ." Chinese botanists (Anonymous, 1972) record that an extract made from its bark and leaves is used as a glue or birdlime.

2. *C. magnificum* (Nakai) Nakai, Cat. Sem. Spor., Hort. Bot. Univ. Imp. Tokyo. 35. 1920. FIGURE 2, r-t.

Forest trees, similar in morphology and growth to *Cercidiphyllum japonicum* but differing in several significant respects; the trees with but a single bole (*vide* Lindquist); the bark remaining smooth, becoming furrowed only at an advanced age; short shoots strongly developed, to ca. 18 mm. long. Long shoot leaves petiolate and stipulate, the petioles 1–2.6 cm. long, the stipules connate, \pm oblong to widely ovate with a bifid apex, ca. 1 mm. long, persistent; leaf blades longer than wide, (2.7–)5–8.3 cm. long, (2–)3–5.8 cm. wide, ovate to elliptic with truncate, rounded, or broadly cuneate bases. Short shoot leaves petiolate and stipulate, the petioles (1.2–)1.7–3.2 cm. long, the stipules connate, ca. 3 mm. long, membranous, \pm broadly ovate with a bifid or trifid apex, persistent and evident at the base

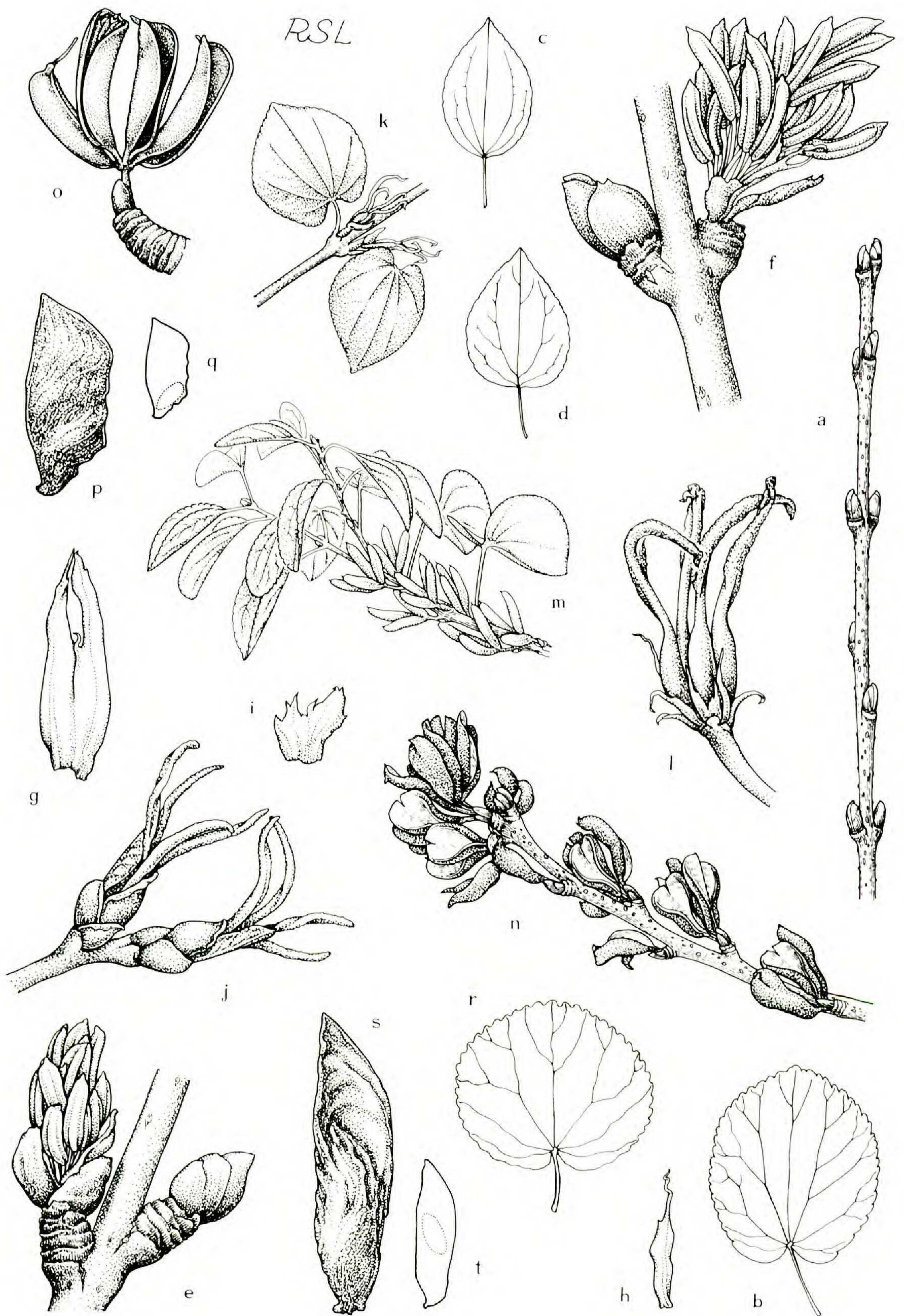


FIGURE 2. *Cercidiphyllum*. a-q, *C. japonicum*: a, portion of long shoot of previous year's growth with dormant winter buds, $\times 1$; b, outline of typical short shoot leaf, showing palmate venation, $\times \frac{1}{2}$; c, d, outline of typical long

of the petiole throughout the growing season; leaf blades glabrous, (3–)4–7(–8.5) cm. long, (2.5–)3.4–7.7(–9.6) cm. wide, broadly ovate, rotund, or reniform, with cordate bases, in herbarium specimens the lobes often overlapping the petiole at the point of its insertion. Inflorescences produced from short shoots in early spring, apparently very similar to those of *C. japonicum*.² Follicles 2–6, clustered together on short peduncles 5–6 mm. long, the peduncles often persistent on the short shoots 2 or 3 years after the follicles have fallen; follicles purplish brown to pinkish, faintly to strongly glaucous, 1.2–2 cm. long, cylindrical, strongly recurved toward the apex and often with a styler beak, at maturity dehiscing only slightly from the apex along the abaxial suture; seeds numerous, small, ca. 6 mm. long, the seed coat creamy tan, the embryo centrally situated, the testa forming small wings at both the distal and proximal ends. $2n = 38$. (*C. japonicum* Sieb. & Zucc. ex J. Hoffm. & Schultes var. *magnificum* Nakai, Bot. Mag. Tokyo 33: 198. 1919; *ibid.* 299. (In Japanese).)

Endemic to Japan on the island of Honshu, where data from herbarium specimens at A and GH indicate its occurrence in Iwate (Mt. Hayachine), Tochigi, Nagano, and Gifu prefectures. Lindquist's (1954) distribution map, showing that *Cercidiphyllum magnificum* is largely confined to the Japanese alps and the Nikko region, essentially coincides with this information. *Cercidiphyllum magnificum* appears to occur in regions where *C. japonicum* is either absent or rare, and Ohwi (1965) states that *C. magnificum* grows at higher elevations than does *C. japonicum*.

Seeds of *Cercidiphyllum magnificum* were received at the Arnold Arboretum from the University of Tokyo in 1920, but I do not know if these seeds were shared with other American or European botanical gardens and arboreta. Unfortunately, none of the plants grown from that seed lot survives in the Arboretum. Subsequent introductions by other institutions (some, perhaps, also in 1920) have established the species in limited numbers in western gardens.

² Only three herbarium specimens representing staminate plants in the later stages of flowering have been available for study. Examination of carpellate plants with follicles in early stages of maturation suggest that the female inflorescences might sometimes consist of only two "flowers" or carpels.

shoot leaves, showing near palmate venation, $\times \frac{1}{2}$; e, early stage of staminate inflorescence protruding from short shoot bud, $\times 3$; f, later stage of staminate inflorescence, the bud scales removed to expose leaf, stipule, and membranous bract, $\times 3$; g, connate stipules of short shoot leaf, $\times 6$; h, i, 2 membranous bracts of staminate inflorescence, $\times 6$; j, expanding short shoot buds with protruding carpellate inflorescences, $\times 3$; k, habit of carpellate inflorescences after partial short shoot leaf expansion, $\times \frac{3}{4}$; l, carpellate inflorescence at stage shown in k, $\times 3$; m, habit of branchlet with immature follicles, $\times \frac{1}{2}$; n, habit of branchlet with fully dehiscent follicles and dormant winter buds, $\times \frac{3}{4}$; o, dehiscent follicles from one inflorescence on short shoot, $\times 2$; p, seed, $\times 6$; q, outline of seed showing position (dotted line) of embryo, $\times 3$. r–t, *C. magnificum*: r, outline of typical short shoot leaf, $\times \frac{1}{3}$; s, seed, $\times 6$; t, outline of seed, showing position (dotted line) of embryo, $\times 3$.

Cercidiphyllum magnificum, while extremely close to *C. japonicum*, can be distinguished by the characters contrasted in the key to species as well as by its larger long shoot leaves, its tendency for the base of the lamina of short shoot leaves to overlap the petiole at its insertion, its strongly recurved, only slightly dehiscent follicles, and its yellowish white seeds. Other, less obvious differences include the bark characters and the tendency for the short shoot leaves of *C. magnificum* to be rounder, with more evenly spaced and prominent crenations.

Plants of *Cercidiphyllum* of pendulous habit with slender, arching and drooping branchlets with the leaves borne on slender petioles 3.4–7 cm. long, the blades 5.5–8 cm. long, 3.6–6.2 cm. wide, ovate to elliptic with rounded, truncate, or broadly cuneate bases and shallowly crenate margins, and the lower surfaces of the blades glaucous, are known in cultivation in Japan and North America. These plants also appear to occur sporadically in the wild in Japan (Mt. Iwayama, Morioka, Iwate Prefecture, *Muroi* 4229 (A), and perhaps elsewhere), and the plants have been recognized taxonomically as either a variety or a form of *C. japonicum*. Based on the morphology of the leaves and stipules, however, the plants are referable not to *C. japonicum*, but to *C. magnificum*. The new combination necessitated is made here.³

Examination of *Cercidiphyllum magnificum* f. *pendulum* reveals that the plants consist entirely of long shoot growth. As a result, the leaves correspond in morphology to long shoot leaves, although of larger dimensions and with longer petioles, and only the one type of leaf is present on the plants. I do not know if juvenility is ever overcome in these plants through the production of short shoots and the concomitant production of flowers. Observations of cultivated plants would be helpful in resolving this question as well as for comparisons with juvenile plants of *C. magnificum* f. *magnificum*.

The few herbarium specimens of *Cercidiphyllum magnificum* f. *pendulum* examined during this study indicate a natural distribution of the form in Iwate Prefecture in northern Honshu. Both *C. japonicum* and *C. magnificum* f. *magnificum* occur in this prefecture (one of the few areas where they may occur together), and this possible coincidence prompts speculation that *C. magnificum* f. *pendulum* might be an interspecific hybrid between the two extant species of *Cercidiphyllum*.

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³ *Cercidiphyllum magnificum* (Nakai) Nakai forma *pendulum* (Miyoshi ex Makino & Nemoto) Spongberg, comb. nov. BASIONYM: *Cercidiphyllum japonicum* Sieb. & Zucc. ex J. Hoffm. & Schultes var. *pendulum* Miyoshi ex Makino & Nemoto, Fl. Jap. ed. 2. 307. 1931. *Cercidiphyllum japonicum* f. *pendulum* (Miyoshi ex Makino & Nemoto) Ohwi, Fl. Jap. 510. 1953.